Can robot-assisted movement training (Lokomat) improve functional recovery and psychological well-being in chronic stroke? Promising findings from a case study

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Summary

The Lokomat is a robotic device that has been widely used for gait rehabilitation in several neurological disorders, with a positive effect also in the chronic phase. We describe the case of a 54-year-old female with post-stroke moderate-to-severe chronic hemiplegia, whose force, gait and balance significantly improved after intensive training with Lokomat Pro. We also noted a positive impact of Lokomat on mood and coping styles. This may be partly related to the task-oriented exercises with computerized visual feedback, which in turn can be considered an important tool for increasing patients’ motor output, involvement and motivation during gait training. Augmented feedback during robot-assisted gait appears to be a promising way of facilitating gait and physical function, but also of improving psychological and cognitive status.

KEY WORDS: Lokomat; chronic stroke, functional recovery, Lokomat, psychological well-being, robotic-assisted rehabilitation

Introduction

Stroke is the leading cause of disability among the elderly in the industrialized world. Indeed, no more than 40% of stroke survivors walk independently, and they do so only after receiving appropriate rehabilitation treatment. Individuals with chronic stroke present an asymmetric posture with reduced weight bearing on the paretic limb, and balance and gait dysfunction, including reduced stride length, cadence and speed of walking, and increased double-support and stance-phase duration in the gait cycle. Thus, restoration of near-normal gait is a major goal in the rehabilitation of stroke patients. Over the past years, beyond conventional physical treatment, various new rehabilitation strategies, including treadmill gait training with body weight support, have been introduced and shown to be effective in improving walking performances (Polese et al., 2013).

The Lokomat is a robotic device, consisting of a powered gait orthosis with integrated computer-controlled linear actuators at each hip and knee joint, a body-weight support system (BWSS), and a treadmill. It has been widely used for gait rehabilitation in several movement disorders, especially in the acute and subacute phases. However, emerging data from the literature, albeit focusing on walking parameters and giving controversial results, are indicating its potential for use also in individuals with chronic neurological disorders, including post-stroke hemiplegia (Kelley et al., 2013; Hornby et al., 2008; Hidler et al., 2009),

Case report

We describe the case of a 54-year-old female with moderate-to-severe hemiparesis and spastic hypertonia following a right frontotemporal ischemic stroke, three years previously. After her severe brain injury, the patient underwent conventional physiotherapy (intensive rehabilitation for three months, followed by home rehabilitation performed two-three times weekly) obtaining moderate functional recovery.

When observed by us (i.e. three years after stroke onset), while hospitalized at IRCCS Neurolesi in Messina, the patient was able to walk with a cane, but only for a few meters.

After a thorough neurological examination covering ambulation and cognition (using the Mini-Mental State Examination), the patient was administered a series of appropriate scales, including the Modified Ashworth Scale, Functional Independence Measure and Tinetti scales to assess her physical status, the Hamilton Rating Scale for Depression, and the Coping Orientation to Problems Experienced test to evaluate psychological status. She then underwent intensive neurorehabilitation treatment. Indeed, besides the standard physical treatment to improve muscle force and tone, the rehabilitation program consisted of walking training with Lokomat Pro (i.e. 40 sessions – five sessions/weekly – each lasting at least 45 minutes), also using its augmented biofeedback software. On completion of the rehabilitation program, we noted a moderate gait and balance improvement, in addition to a significant increase in the patient's force, with regard to right hip extension (as tested by specific Lokomat software) (Table I). Moreover, her mood and cognitive status and coping strategies also improved significantly ($p<0.05$) compared with the results obtained in three other female patients with chronic stroke, who underwent the same rehabilitation training but without the use of a robotic tool (i.e. ambulation was performed on a BWSS treadmill with therapist assistance) (Table II).

Discussion

To the best of our knowledge, this is the first report on the potential benefit of Lokomat training on general functional and psychological status. Several controlled trials showed a superior effect of Lokomat in acute stroke patients with respect to walking ability and gait velocity (patients walk more symmetrically, and higher velocities result in a facilitation of paretic muscles and render gait more efficient). However, to date, few studies have examined robot-assisted gait rehabilitation in chronic stroke. Kelley et al. (2013), in their blinded randomized clinical trial, found no significant differences in gait velocity, endurance or functional level between two groups of chronic stroke survivors undergoing either Lokomat or traditional overground gait training. Moreover, Hornby et al. (2008) showed greater improvements in speed and single limb stance time on the impaired leg in those subjects who received therapist-assisted locomotor training. Interestingly, they noted an improvement in the perceived rating of the effects of physical limitations on quality of life only in individuals with severe gait deficits.

Table I - Computerized force evaluation using specific Lokomat software before (T0) and after (T1) treatment.

	T0	T1
HIP FORCE (Nm)		
Left hip flexion	27	30
Right hip flexion	22	28
Left hip extension	0	1
Right hip extension	6	76
KNEE FORCE (Nm)		
Left knee flexion	0	6
Right knee flexion	13	34
Left knee extension	1	3
Right knee extension	40	40

Our patient, after undergoing intensive Lokomat training, showed a significant improvement both in functional and psychological and cognitive status.

This positive impact of Lokomat on mood and coping styles may be partly related to the task-oriented exercises with computerized visual feedback, which can be considered an important tool for increasing patients' motor output, involvement, and motivation during gait training (Banz et al., 2008).

Moreover, we may argue that the effect of this advanced robotic gait training on cognition may be due either to the improvement in attention/motivation (the integrated biofeedback system monitors the patient's gait and provides real-time visual performance feedback to encourage the patient's active participation) or to the improvement in mood, given that depression may worsen cognitive impairment.

In conclusion, robot-assisted movement training may improve not only motor function, including gait, balance and muscle force, but also mood, cognition, and coping strategies, as shown by this pilot case study. Nonetheless, larger studies focusing on the potential effect of robotic rehabilitation on neuropsychological status, functional outcomes, and quality of life should be encouraged in order to confirm these promising findings.

Table II - Clinical evaluation before (T0) and after (T1) rehabilitation treatment in the patient and three matched controls.

	Case		Control 1		Control 2		Control 3		
	T0	T1	T0	T1	T0	T1	T0	T1	p-value
Tinetti scale (balance)	12	15	13	12	8	8	11	11	ns
Tinetti scale (gait)	6	12	6	6	8	9	9	9	s
Ashworth lower left	3	2	3	3	2	2	3	3	ns
FIM	100	119	86	92	78	82	89	95	s
MMSE	21.6	26.6	22.3	24	20.6	22.6	20.9	21.9	s
HRS-D	13	5	10	10	12	10	10	8	s
COPE TEST									
Social support	16	33	22	24	19	22	22	22	s
Avoidance strategies	29	13	26	30	19	24	21	23	s
Positive attitude	21	29	21	18	21	19	19	18	s
Problem solving	18	28	23	25	23	20	22	24	s
Turning to religion	25	26	23	25	27	27	22	22	ns

Differences in post-treatment improvement between them were assessed using $p<0.05$ to denote statistical significance.
Abbreviations: FIM=Functional Independence Measure; MMSE=Mini-Mental State Examination; HRS-D=Hamilton Rating Scale for Depression; COPE=Coping Orientation to Problems Experienced

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